

ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
Washington, D.C. Ottawa, Ontario
30 SEPTEMBER 1972



COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

C A N A D A · U N I T E D S T A T E S

CANADIAN SECTION

G. M. MacNABB, Chairman
A. F. PAGET, Member

UNITED STATES SECTION

J. M. CALDWELL, Chairman
J. W. NEUBERGER, Member

31 December 1972

The Honorable William P. Rogers
The Secretary of State
Washington, D.C.

The Honourable D.S. Macdonald
Minister of Energy, Mines and
Resources
Ottawa, Ontario

Gentlemen:

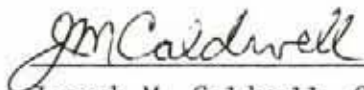
Reference is made to the Treaty between the United States of America and Canada, relating to co-operative development of the water resources of the Columbia River basin, signed at Washington, D.C., on 17 January 1961.

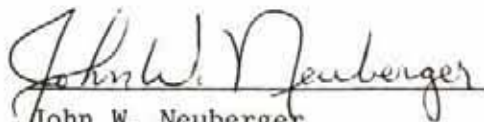
In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the eighth Annual Report, dated 30 September 1972, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1971 to 30 September 1972.

Respectfully submitted:

For the United States

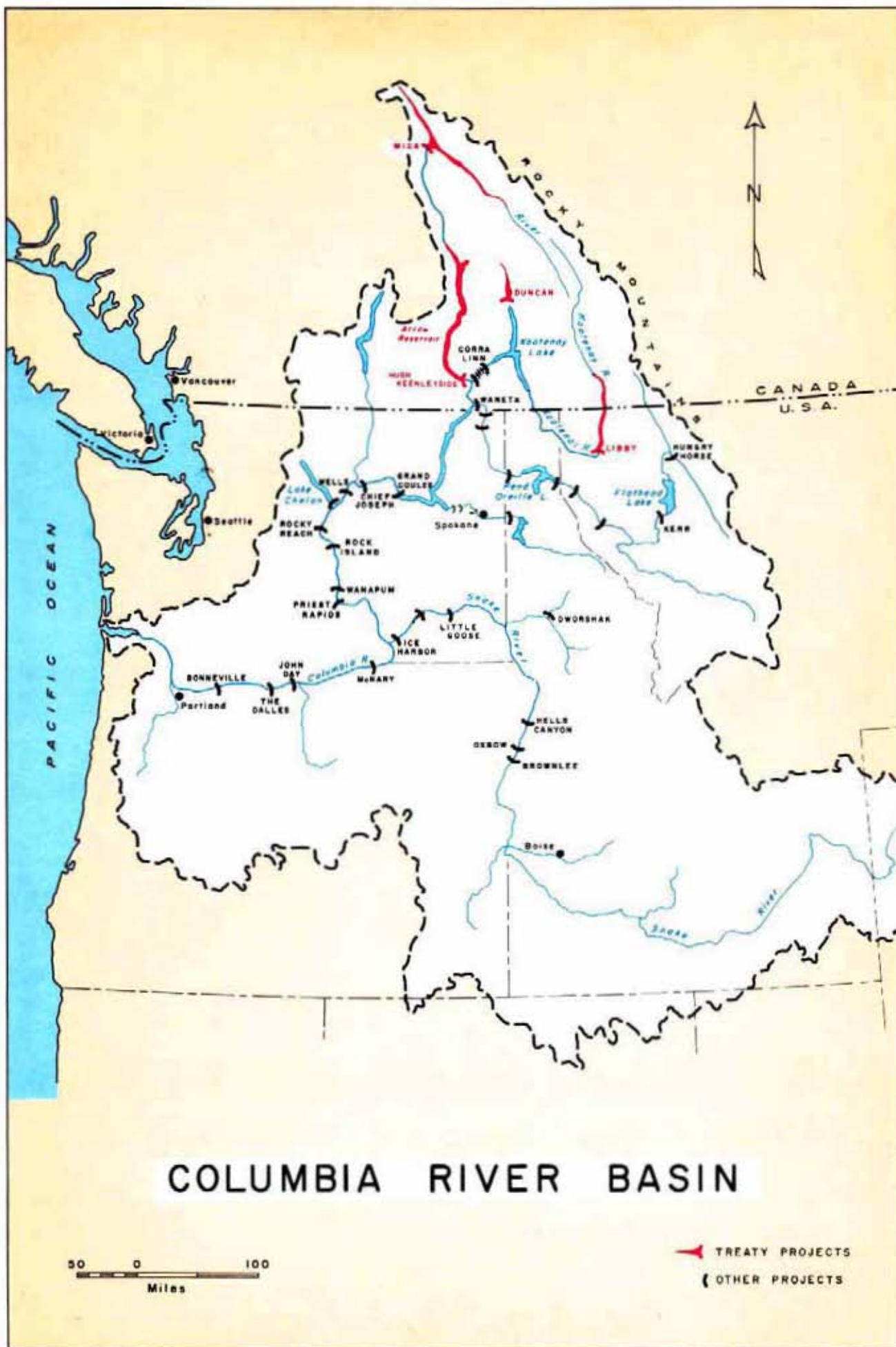

Joseph M. Caldwell, Chairman


John W. Neuberger

For Canada


G.M. MacNabb, Chairman


A.F. Paget



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COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C.

Ottawa, Canada

30 September 1972

CONTENTS

	<u>Page</u>
Letter of Transmittal	
Frontispiece	
SUMMARY	viii
INTRODUCTION	1
THE COLUMBIA RIVER TREATY	
General	2
Features of the Treaty and Related Documents	4
PERMANENT ENGINEERING BOARD	
General	6
Establishment of the Board	6
Duties and Responsibilities of the Board	7
ENTITIES	
General	9
Establishment of the Entities	9
Powers and Duties of the Entities	10

ACTIVITIES OF THE BOARD

Meetings and Field Inspections	13
Reports Received	13
Report to Governments	15

PROGRESS

General	17
Construction Progress of the Treaty Projects	
Mica Project	17
Libby Project in the United States	21
Libby Project in Canada	25
Hydrometeorological Network	27
Power Operating Plans	28
Annual Calculation of Downstream Benefits	29
Flood Control Operating Plans	30
Flow Records	31

OPERATION

General	32
Power Operation	33
Additional Storage on Arrow Reservoir	37
Flood Control Operation	38

BENEFITS

Flood Control Payment	39
Flood Control Provided	39
Power Benefits	41

CONCLUSIONS	42
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LIST OF PHOTOGRAPHS

	<u>Page</u>
Hugh Keenleyside Dam	3
Lake Koocanusa Bridge	7
Log Boom, Libby Project	10
Mica Spillway	12
Mica Project	16
Mica Dam Crest	18
Mica Power Intakes	19
Mica Spillway Flip Bucket	20
Libby Dam	22
Lake Koocanusa, Relocated Highway at Libby Dam	23
Libby Dam, Left Abutment	24
Kikomun Bridge, Libby Project	25
Wardner Bridge, Libby Project	26
Libby Dam, Downstream Face	28
Diversion Tunnel Plug, Mica Project	31
Mica Outlet Works Intake	32
Mica Access Bridge	36
Libby Dam, Selective Withdrawal Structure	37
Mica Diversion Tunnels Discharging	38

Photographs supplied by the British Columbia Hydro and
Power Authority, the Government of British Columbia
and the Corps of Engineers, U.S. Army.

HYDROGRAPHS

	<u>Page</u>
Duncan and Arrow Reservoir Levels	34
Observed and Pre-project Flows	40

APPENDICES

Appendix A - Names of Board Members, Alternates, and Secretaries .	43
Appendix B - Names of Members of the Entities	44
Appendix C - Record of Flows at the International Boundary	45
Appendix D - Plates	48

SUMMARY

The eighth Annual Report of the Permanent Engineering Board is submitted to the Governments of the United States and Canada in compliance with Article XV of the Columbia River Treaty of 17 January 1961. Project construction, progress of Entity studies, operation of the Arrow, Duncan and Libby reservoirs, and the resulting benefits are described.

Two Board meetings and one meeting of the Board with the Entities were held during the reporting period. The Board also inspected the Mica and Libby projects during the month of August 1972. Work on both projects is on schedule and full storage operation will commence in April 1973.

The Arrow and Duncan reservoirs have been operated in accordance with the objectives of the Treaty, the terms of the operating plans developed by the Entities, and the interim flood control operating plan for Duncan and Arrow reservoirs. The partial operation of Libby storage which commenced on 21 March 1972 was carried out in a manner which was consistent with Treaty criteria. Major flood damage in both Canada and the United States was averted in 1972 through regulation provided by these projects.

Studies pertaining to development of the hydrometeorological network and power and flood control operating plans are being continued by the Entities to ensure operation of the projects in accordance with the terms of the Treaty. Downstream power benefits are being calculated by the Entities as required by the Treaty.

The Board concludes that the objectives of the Treaty are being met.

INTRODUCTION

The Columbia River Treaty, which provides for co-operative development of the water resources of the Columbia River basin, was signed in Washington, D.C. on 17 January 1961 by representatives of the United States and Canada. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties would be to "make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty...."

This Annual Report, which covers the period 1 October 1971 to 30 September 1972, describes activities of the Board, progress being achieved by both countries under the terms of the Treaty, operation of the Treaty projects, and the resulting benefits. The report also states that, in the opinion of the Board, the objectives of the Treaty are being met. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included.

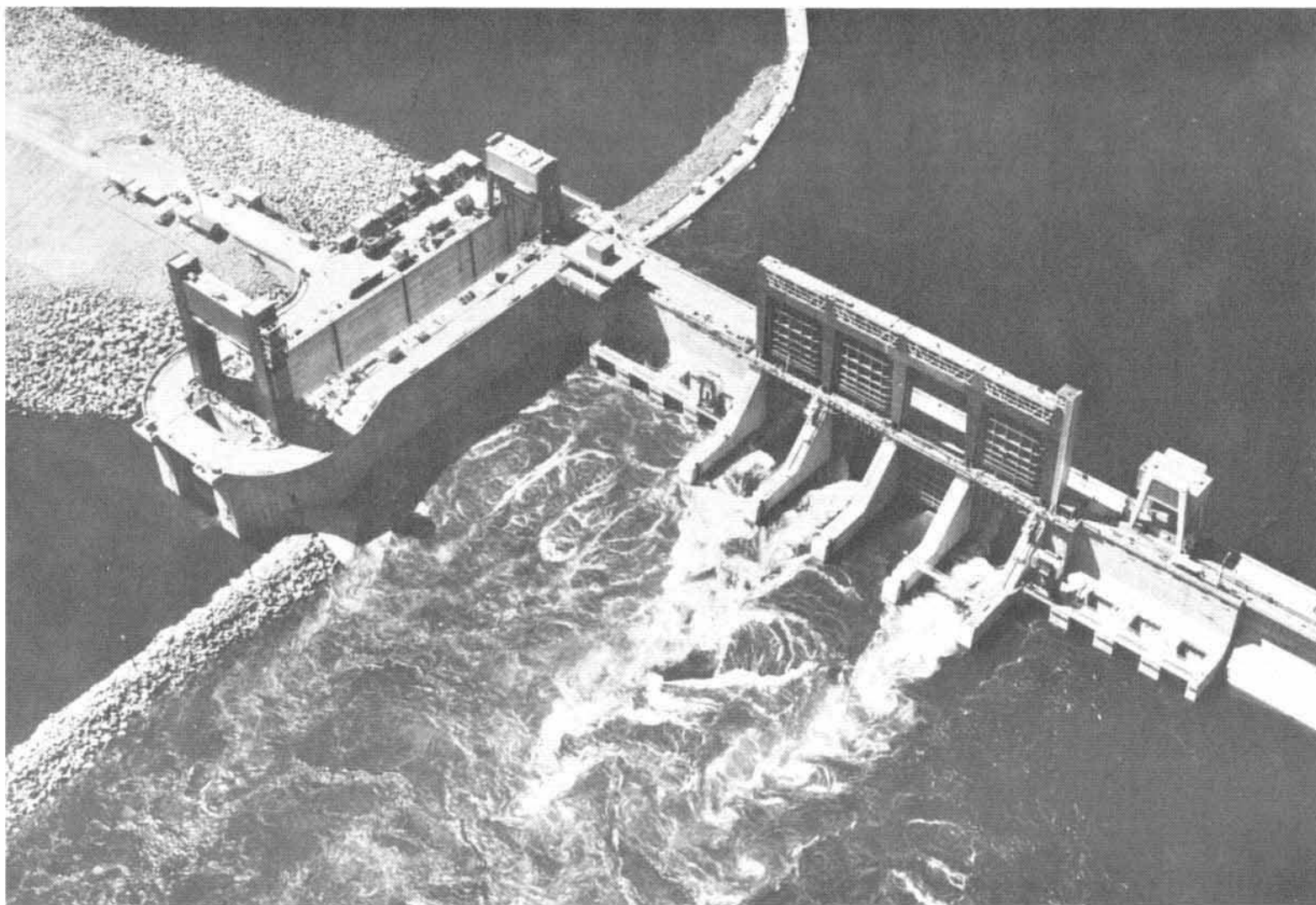
THE COLUMBIA RIVER TREATY

General

The Columbia River Treaty was signed in Washington, D.C. on 17 January 1961 and was ratified by the United States Senate in March of that year. In Canada ratification was delayed. Further negotiations between the two countries resulted in formal agreement by an exchange of notes on 22 January 1964 to a Protocol to the Treaty and to an Attachment Relating to Terms of Sale. The Treaty and related documents were approved by the Canadian Parliament in June 1964.

The Canadian Entitlement Purchase Agreement was signed on 13 August 1964. Under the terms of this agreement Canada's share of downstream power benefits resulting from the first thirty years of scheduled operation of each of the storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964 the Treaty and Protocol were formally ratified by an exchange of notes between the two governments. The sum of \$253.9 million (U.S. funds) was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date at a ceremony at the Peace Arch Park on the International Boundary the Treaty and its Protocol were proclaimed by President Johnson, Prime Minister Pearson, and Premier Bennett of British Columbia.



HUGH KEENLEYSIDE DAM

Columbia River, British Columbia

Discharging from Arrow reservoir at freshet time; the navigation lock is to the left of the outlet works.

Features of the Treaty and Related Documents

The essential features of the Treaty are as follows:

- (a) Canada will provide 15.5 million acre-feet of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes, and Duncan Lake, in British Columbia.
- (b) The United States will maintain and operate hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved stream flow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with procedures and operating plans specified in the Treaty.
- (c) The United States and Canada will share equally the additional power generated in the United States as a result of river regulation by upstream storage in Canada.
- (d) On commencement of the respective storage operations the United States will make payments to Canada totalling \$64.4 million (U.S. funds) for flood control provided by Canada.
- (e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby reservoir would extend some 42 miles into Canada and Canada would make the necessary Canadian land available for flooding.

- (f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984 Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.
- (g) Differences arising under the Treaty which cannot be resolved by the two countries may be referred by either to the International Joint Commission or to arbitration by an appropriate tribunal as specified by the Treaty.
- (h) The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964.

The Protocol of January 1964 amplified and clarified certain terms of the Columbia River Treaty. The Attachment Relating to Terms of Sale signed on the same date established agreement that under certain terms Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Canadian Entitlement Purchase Agreement of 13 August 1964 provided that the Treaty storages would be operative for power purposes on the following dates:

Duncan storage	1 April 1968
Arrow storage	1 April 1969
Mica storage	1 April 1973

PERMANENT ENGINEERING BOARD

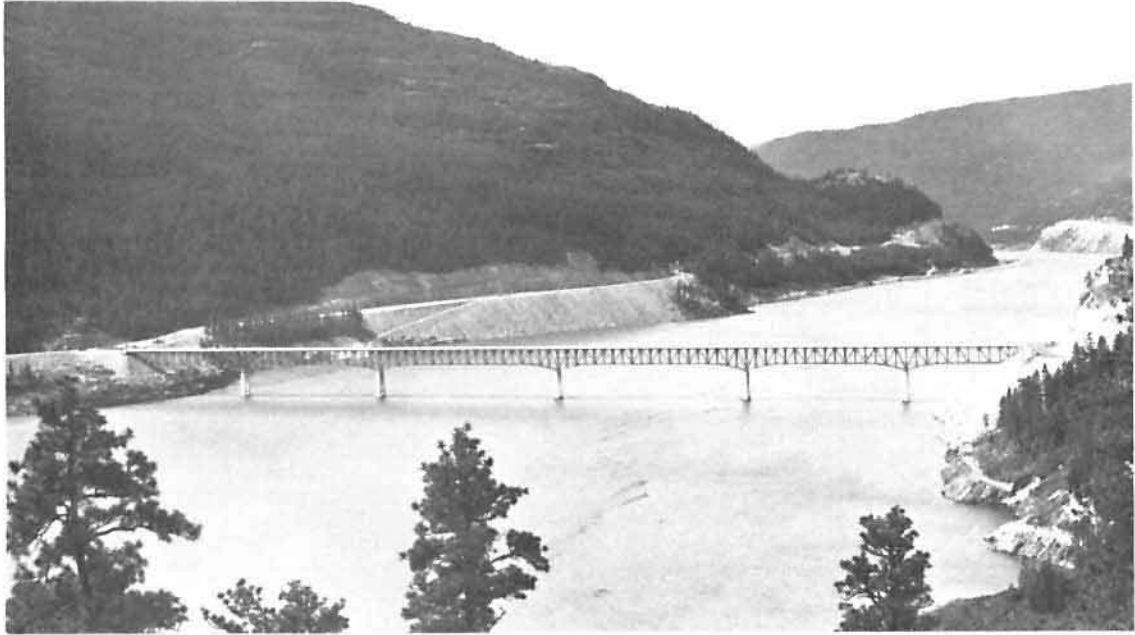
General

Article XV of the Columbia River Treaty established a Permanent Engineering Board consisting of two members to be appointed by Canada and two members by the United States. Appointments to the Board were to be made within three months of the date of ratification. The duties and responsibilities of the Board were also stipulated in the Treaty and related documents.

Establishment of the Board

Pursuant to Executive Order No. 11177 dated 16 September 1964 the Secretary of the Army and the Secretary of the Interior on 7 December 1964 appointed two members and two alternate members to form the United States Section of the Permanent Engineering Board. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671 dated 29 October 1964. Each member was authorized to appoint an alternate member. On 11 December 1964 the two governments announced the composition of the Board.

The names of the Board members, alternate members and secretaries are shown in Appendix A. It is noted that Mr. Walter W. Duncan has replaced Mr. Verle Farrow as Secretary of the United States Section of the Board.



LAKE KOOCANUSA BRIDGE linking highways in Montana.

July 1972.

Duties and Responsibilities of the Board

The general duties and responsibilities of the Board to the governments, as set forth in the Treaty and related documents, include:

- (a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada-United States of America boundary;
- (b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and if appropriate including in the report recommendations for remedial action and compensatory adjustments.

- (c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;
- (d) making periodic inspections and requiring reports as necessary from the entities with a view to ensuring that the objectives of the Treaty are being met;
- (e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter which it considers should be brought to their attention;
- (f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America;
- (g) consulting with the entities in the establishment and operation of a hydro-meteorological system as required by Annex A of the Treaty.

ENTITIES

General

Article XIV(1) of the Treaty provides for the designation by Canada and the United States of entities which are empowered and charged with the duty of formulating and executing the operating arrangements necessary to implement the Treaty. Provision is made for either government to designate one or more entities. The powers and duties of the entities are specified in the Treaty and related documents.

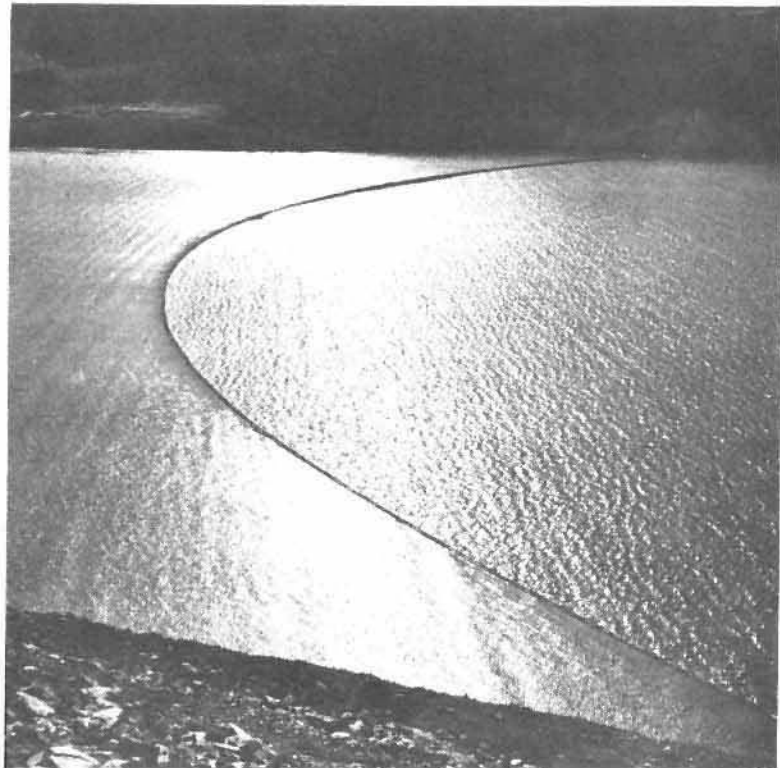
Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration, Department of the Interior, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of the Army, as the United States Entity with the Administrator to serve as Chairman. Order in Council P.C. 1964-1407 dated 4 September 1964 designated the British Columbia Hydro and Power Authority as the Canadian Entity for the purposes of the Treaty.

The names of the members of the two entities are shown in Appendix B.

LOG BOOM

in Lake Kootenai
to keep driftwood
away from Libby Dam.
July 1972.



Powers and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents the Treaty requires that the entities be responsible for:

- (a) co-ordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty,
- (b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control,

- (c) calculation of the amounts payable to the United States of America for standby transmission services,
- (d) consultation on requests for variations made pursuant to Articles XII(5) and XIII(6),
- (e) the establishment and operation of a hydrometeorological system as required by Annex A,
- (f) assisting and co-operating with the Permanent Engineering Board in the discharge of its functions,
- (g) periodic calculation of accounts,
- (h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled,
- (i) preparation of proposals to implement Article VIII and carrying out any disposal authorized or exchange provided for therein,
- (j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled including such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss,

- (k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in Annexes A and B.

Article XIV(4) of the Treaty provides that the two governments may, by an exchange of notes, empower or charge the entities with any other matter coming within the scope of the Treaty.



MICA SPILLWAY control structure and chute.

June 1972.

ACTIVITIES OF THE BOARD

Meetings and Field Inspections

The first meeting of the Board during the report year was held in Portland, Oregon on 16 November 1971, followed by a meeting with the Entities to review and discuss Entity studies and general progress under the Treaty. The second meeting of the Board was held in Spokane, Washington on 22 August 1972. The Board inspected the Mica and Libby projects on 21 and 22 August 1972 to assess construction progress and on 23 August visited the Grand Coulee project.

Reports Received

The Board received semi-annual progress reports from the Entities. These reports included construction progress reports on the Mica and Libby projects, a record of documents approved by the Entities, and a general outline of reservoir operations and Entity studies.

Throughout the report year the Canadian Entity provided the Board with weekly reports on operation of the Canadian storage reservoirs and with daily flow forecasts during the freshet season. The Entities also provided copies of computer printouts of studies for the Assured Operating Plan and downstream power benefit calculation, and the following documents and reports:

- Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1970 to 30 September 1971
- Report on Operation of Columbia River Treaty Projects 1 August 1970 through 31 July 1971
- Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1976-77, plus a copy of the Entities' agreement on this document
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1976-77, plus a copy of the Entities' agreement on this document
- Detailed Operating Plan for Columbia River Treaty Storage 1 July 1971 through 31 July 1972, plus a copy of the Entities' agreement on this document
- Operating Plans with Mica Generation
- Runoff Volume Forecast Program for Canadian Columbia River Treaty Reservoirs
- Columbia River Treaty Hydrometeorological System Plan for Exchange of Operational Hydromet Data, plus a copy of the Entities' agreement on this document
- Columbia River Treaty Hydrometeorological System Treaty Facilities, plus a copy of the Entities' agreement on this document
- Columbia River Treaty Hydrometeorological Supporting Facilities.

Subsequent to the end of this report year the Board received the following documents and reports from the Entities:

- Columbia River Treaty Flood Control Operating Plan
- Detailed Operating Plan for Columbia River Treaty Storage 1 July 1972 through 31 July 1973, plus a copy of the Entities' agreement on this document
- Report on Operation of Columbia River Treaty Projects 1 August 1971 through 31 July 1972
- Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1971 to 30 September 1972
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1977-78, plus a copy of the Entities' agreement on this document
- Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1977-78, and Downstream Power Benefit Computations for 1977-78 Operating Year, plus a copy of the Entities' agreement on these documents.

During the report year arrangements were made for additional storage in the Arrow reservoir. Copies of letters pertaining to this storage were provided to the Board by the Canadian Entity. The operation of this additional storage is discussed on page 37.

Report to Governments

The seventh Annual Report of the Board was submitted to the two governments on 31 December 1971.



MICA PROJECT

The dam and spillway almost complete during the 1972 freshet.

Columbia River, British Columbia

June 1972.

PROGRESS

General

The results achieved under the terms of the Treaty include progress on construction of the Treaty projects and on studies regarding development of the hydrometeorological network, power and flood control operating plans, and the annual calculation of downstream power benefits. Duncan Dam was placed in operation on 31 July 1967. The Arrow project was declared operational on 10 October 1968 and the dam was named the Hugh Keenleyside Dam on 9 June 1969. Both projects were completed well in advance of Treaty requirements and continued to produce power and flood control benefits during this report year. The Hugh Keenleyside Dam is shown in the picture on page 3 and the locations of the Treaty projects are shown on Plate 1.

Construction Progress of the Treaty Projects

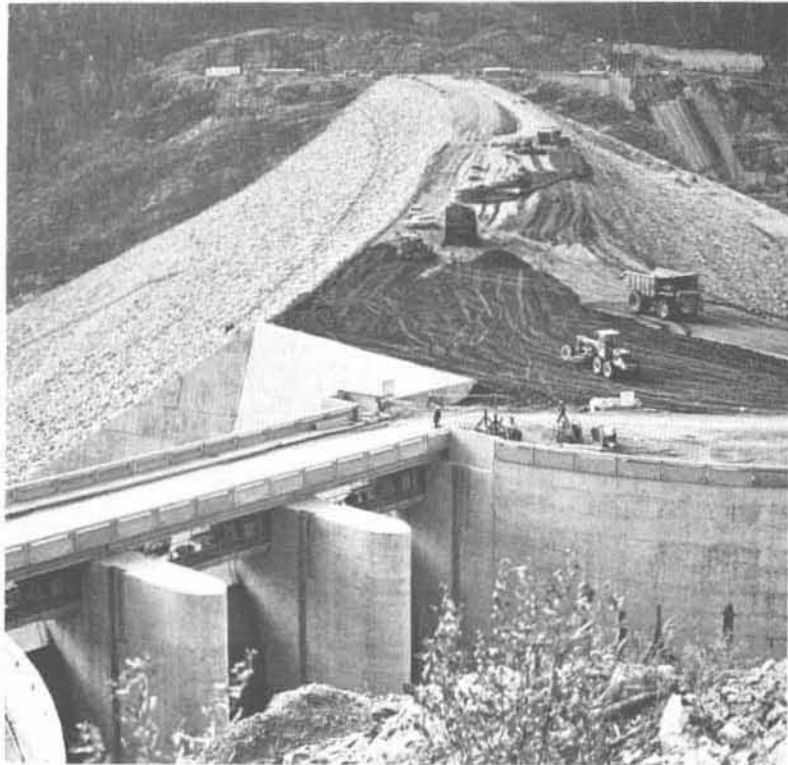
Mica Project

Mica dam, the largest of the Treaty projects, is scheduled by the Sales Agreement for initial operation on 1 April 1973.

The general arrangement of structures for the Mica project is shown on Plate 2. The main dam has a nearly vertical impervious core supported between zones of coarser material. Two 45-foot diameter tunnels were constructed in the left abutment

MICA DAM CREST

Looking across
spillway approach channel
to finishing work on
earth fill dam.
October 1972.



for river diversion. Spillway facilities and control works to provide regulated discharges from storage are located in the left abutment and power facilities are being constructed underground in the right abutment.

Construction of the Mica project is on schedule. At the end of the previous report year the main dam fill had reached elevation 2335 feet and was 635 feet above the bedrock foundation, the spillway was nearly complete and work on the power intake tunnels and gate shafts was well advanced. By the end of this report year the dam was essentially complete and by 14 October 1972 all granular fill was in place, the top of the dam was at elevation 2500 feet for its full length, and only a small amount of riprap high on the upstream face of the dam was required to complete the structure. The dam rises about 800 feet above the bedrock

foundation and contains some 42,700,000 cubic yards of material. The crest was constructed to a width of 110 feet as a precautionary measure to ensure safety of the structure against overtopping which might result if a landslide were to occur in the reservoir area. The completed fill is shown on Plate 3 and in the picture on page 18.

The two tunnels constructed for river diversion are being modified to provide for release of water from the lower portion of the reservoir without passing flows through the powerhouse. Tunnel number 2 has been closed and smaller water conduits and energy dissipating facilities are being installed for use as low level outlets during the initial filling period. The permanent outlet works controlled at the intake tower shown on Plate 2 and in the picture on page 32 will discharge into tunnel number 1. Construction of these facilities is well advanced.

MICA POWER INTAKES

concrete work
nearing completion.
September 1972.



The spillway with the flip bucket energy dissipator is complete except for minor finishing and cleanup. Concrete work for the power intakes is nearly complete.

Early in 1972 the British Columbia Hydro and Power Authority awarded a contract for constructing access tunnels and roads for the underground powerhouse. Good progress is being made with both the tunnelling and road work more than half completed. Contracts have also been awarded for the supply of four turbines and generators and a contract for the powerhouse is to be awarded in November 1972. There will be space for six units with a total capacity of 2,610,000 kw; the first two 435,000 kw generators are scheduled for service in 1976.

The project area is shown on Plate 4. The clearing program in the reservoir is about 90 percent complete.

MICA SPILLWAY
flip bucket
nearing completion.
June 1972.



Libby Project in the United States

Libby dam is the fourth and last of the Treaty projects to be placed under construction. Initial phases, including highway and railroad relocations, were commenced in June 1966. In accordance with Article XII of the Treaty the dam is to be operational by 30 June 1973.

The general arrangement of the structures is shown on Plate 5, and the reservoir area and the required highway and railroad relocations are depicted on Plate 6. The concrete gravity dam will be capable of storing water up to elevation 2459 feet, and the reservoir, with a total length of 90 miles, will extend some 42 miles into British Columbia. Procurement and preparation of the land required for the portion of the reservoir in Canada is, in accordance with the terms of the Treaty, the obligation of the Canadian Government. By subsequent agreement between Canada and the Province of British Columbia on 8 July 1963, British Columbia undertook responsibility for these flowage costs in Canada.

Overall project construction of the dam, reservoir, new bridges and relocations is 80 percent complete, and the dam is 99 percent complete; construction is on schedule. Work necessary to provide full operational capabilities for storage of water by 30 June 1973 to fulfill the requirements of the Treaty is on schedule. Construction progress is shown in the picture on page 22. All of the concrete for the dam has been placed except for a portion of the Treaty tower.



LIBBY DAM

Kootenai River, Montana

In partial operation with the reservoir filled to elevation 2404. The powerhouse area is in the centre foreground. July 1972.

The pool was filled to elevation 2404.5 feet during the spring of 1972 following closure of the three temporary sluices. At the end of the report year the pool was being drawn down to elevation 2230 feet to facilitate the construction of a buttress upstream of the dam on the left bank. During the 1973 spring runoff, the pool will be raised for a second time and will be allowed to reach full pool elevation 2459 feet. The contract for the construction of the powerhouse was awarded on 21 April 1972. Mobilization is complete and initial concrete placement has begun in the foundation area. Construction is on schedule with approximately 6 percent completed. The powerhouse construction at Libby dam is not part of the Treaty and is not contrary to any of the Treaty provisions.



LAKE KOOCANUSA and left abutment of Libby Dam showing relocated highway and potential slide area.
July 1972.

LIBBY DAM

from left abutment;
reservoir is at maximum
level for this year.
July 1972.



Construction of the first phase of the selective withdrawal structure was completed in March 1972. Bids for the second phase will be opened on 27 October 1972, with this construction work to be completed ahead of the pool rise next spring. The selective withdrawal structure will make it possible to draw water for the turbines from various levels in the reservoir in order to control the temperature and oxygen content of water released downstream.

All contracts on relocated Montana State Highway No. 37, along the east bank of the reservoir, are in progress or completed. This relocation work is now 79 percent complete. All Forest Development roads have been built with the completion of the last unit in September 1972.



KIKOMUN BRIDGE crossing the Libby reservoir in British Columbia. Summer 1972.

Libby Project in Canada

Negotiations for the acquisition of the remaining privately-owned property have been progressing rather slowly owing to owner resistance to financial settlements: 1,650 acres or about 20 percent have yet to be acquired but expropriation procedures in hand will ensure completion on schedule. The British Columbia Forest Service have now cleared completely 8,925 acres or 97 percent of the estimated total of 9,240 acres of forested land.

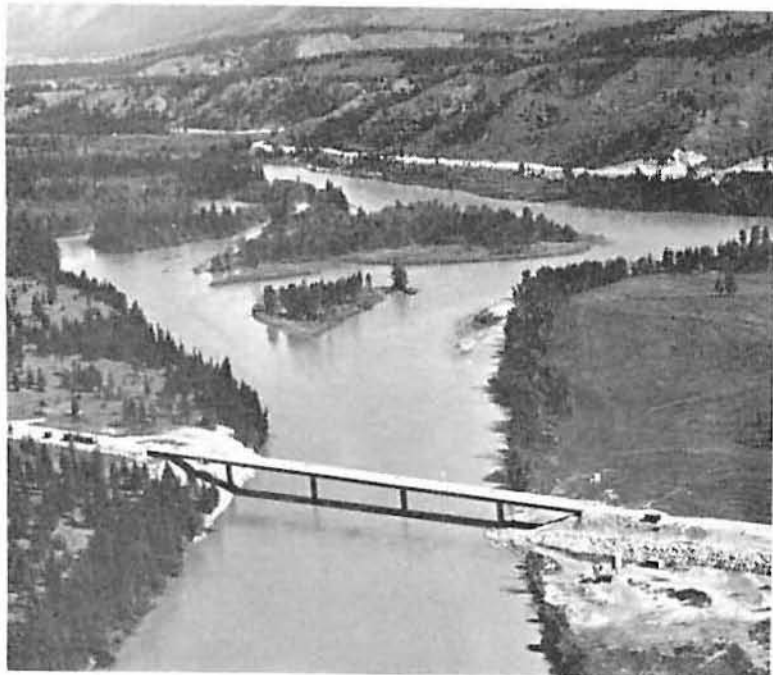
As noted earlier, partial filling of the reservoir up to elevation 2405 feet commenced during the spring of 1972 and filling to full pool elevation of 2459 feet is scheduled to commence in the spring of 1973.

All new roads necessitated by the flooding are now complete. The Wardner highway bridge and the Canadian Pacific Railway overpass at Wardner have been constructed. The Kikomun and Gold Creek bridges were opened to traffic on 12 June 1972 and 19 June 1972 respectively.

A joint study by the Government of British Columbia and Canadian Pacific Railway, to evaluate compensation for track modifications between Fort Steele and Wardner made necessary by the reservoir, is now finished. It is anticipated that the modifications will be completed in 1973.

WARDNER BRIDGE

carrying British Columbia
trans-provincial highway
across upper end of
Libby reservoir.
Summer 1972.



Hydrometeorological Network

One of the responsibilities assigned to the Entities by the Treaty is the establishment and operation, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for detailed programming of flood control and power operation. This system includes snow courses, meteorological stations and streamflow gauges.

In developing the hydrometeorological network the Entities, with the concurrence of the Board, adopted a document which defines the Columbia River Treaty Hydrometeorological System Network and sets forth a method of classifying facilities into those required as part of the Treaty System and those of value as Supporting Facilities. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities, makes recommendations on establishing the Treaty Hydrometeorological System.

In 1970 the Entities, with the concurrence of the Board, adopted Recommendation No. 6 which outlines an interim plan for exchange of hydrometeorological data. In this report year, 1 October 1971 to 30 September 1972, the Entities, with Board concurrence, adopted a revised interim plan that includes operational data for the Mica and Libby projects.

During the report year the Entities, with the concurrence of the Board, revised the consolidated listing of Treaty Facilities. The Entities also provided the Board with a revised listing of Supporting Facilities.



LIBBY DAM

Kootenai River, Montana

In partial operation during the 1972 freshet. Part of the construction trestle for cranes has been removed.
July 1972.

Power Operating Plans

The Treaty and related documents provide that before any of the Canadian storage becomes operative the Entities will agree on operating plans and downstream power benefits for each ensuing year until the total of 15,500,000 acre-feet of storage in Canada becomes operative. In addition, based on the terms of the Treaty, the Entities are to agree annually on operating plans and on the resulting downstream power benefits for the sixth succeeding year of operation.

In September 1970 the Entities agreed on hydroelectric operating plans for Canadian storage for the operating year 1 July 1975 through 30 June 1976. The operating plan for operating year 1976-77 which was delayed due to the complexity of including, for the first time, generation at the Mica project was completed early in 1972 and reviewed by the Board. It does not depart substantially from the plan for 1975-76. The operating plan for 1977-78, due earlier this year, was delayed because of the complexities in planning the operation of the four generating units at Mica and the requirement to produce optimum generation in both Canada and the United States. It was received from the Entities after the end of the report year.

Early in this report year the Entities provided the Board with a detailed operating plan for Canadian storage for the operating year ending 31 July 1972. A detailed operating plan for the operating year ending 31 July 1973 was forwarded to the Board after the end of this report year.

Annual Calculation of Downstream Benefits

The general requirements for determination of assured operating plans and downstream power benefits are summarized in the first paragraph of the preceding section.

In this report year the Entities provided the Board with a copy of their agreed document outlining downstream power benefits resulting from Canadian storage for

the operating year 1976-77. The Board has completed its review of this document and concludes that it meets the requirements of the Treaty. Copies of the three computer studies used in the final calculations for the determination of downstream benefits and which also provide the basis of the hydroelectric operating plan were forwarded to the Board by the Entities. This material facilitated review of the documents by the Board. The calculation of downstream power benefits for the operating year 1977-78 is based on the studies required to develop the operating plan and was also delayed due to the inclusion of generation at Mica and the need to optimize generation in both countries. Reports on this were received from the Entities after the end of the report year.

Flood Control Operating Plans

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada.

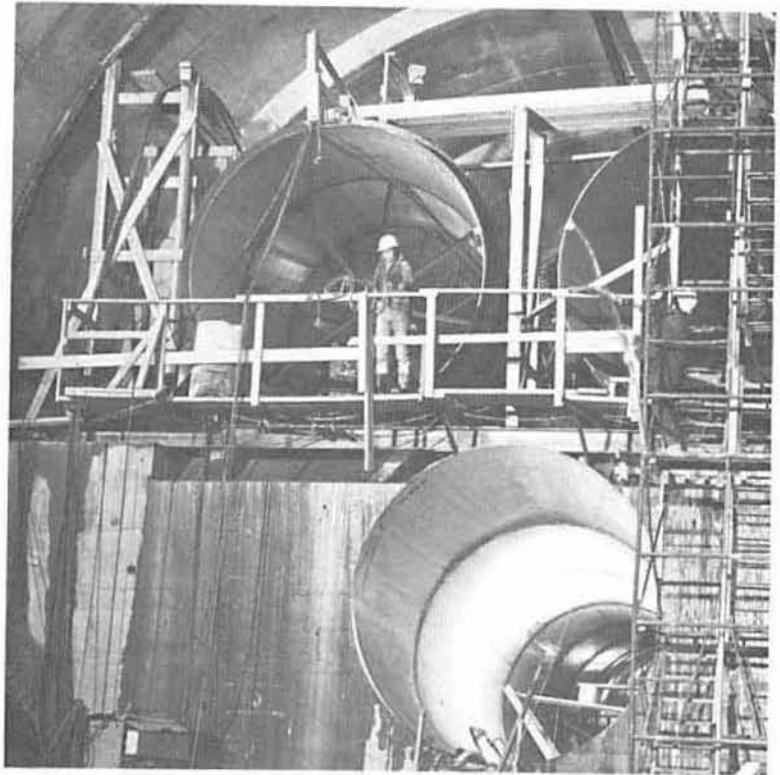
In the 1968-69 report year the Entities reached agreement on an interim flood control plan for the Duncan and Arrow reservoirs which will govern flood control operations until Libby and Mica become operational. The Entities provided the Board with a copy of the interim plan at that time. The "Columbia River Treaty Flood Control Operating Plan" which is to replace the interim plan was received from the Entities after the end of the report year.

Flow Records

Article XV(2)(a) of the Treaty specified that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay Rivers at the Canada-United States of America boundary. Actual recorded flows for the Kootenai River at Porthill, Idaho, and for the Columbia River at Birchbank, British Columbia, (see Plate 1) are tabulated in Appendix C for this report year.

DIVERSION TUNNEL PLUG

with water conduits for
low level outlets,
Mica Project.
October 1972.



OPERATION

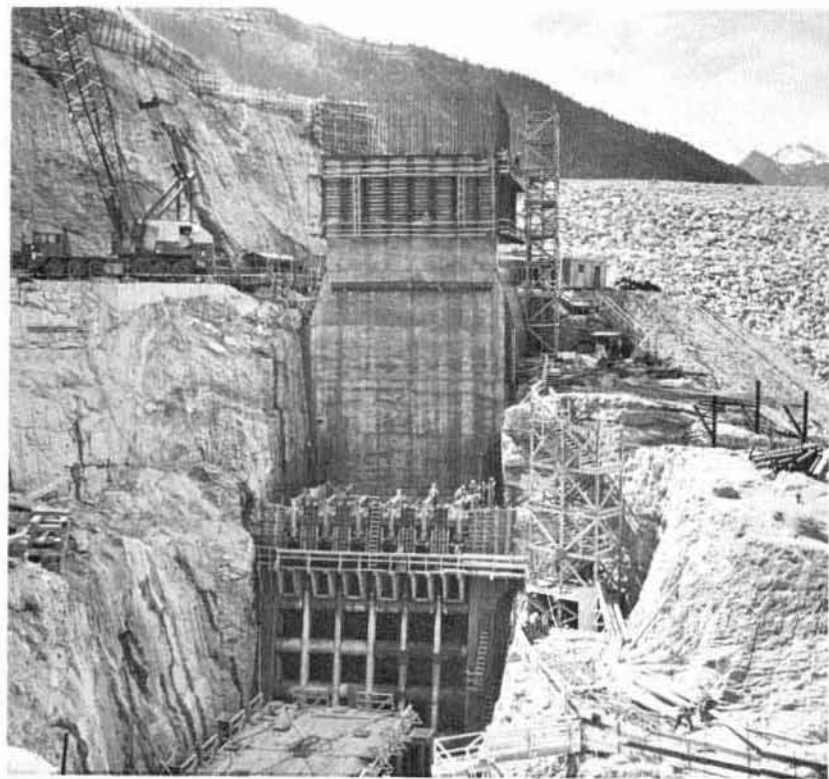
General

The Columbia River Treaty Operating Committee was established by the Entities to develop operating plans for the Treaty storages and to direct operation of these storages in accordance with the terms of the Entity agreements.

During the report year the Treaty storage in Canada was operated by the Canadian Entity in accordance with the "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs", the "Detailed Operating Plan for Columbia River

MICA OUTLET WORKS

intake tower
with trash grillage.
July 1972.

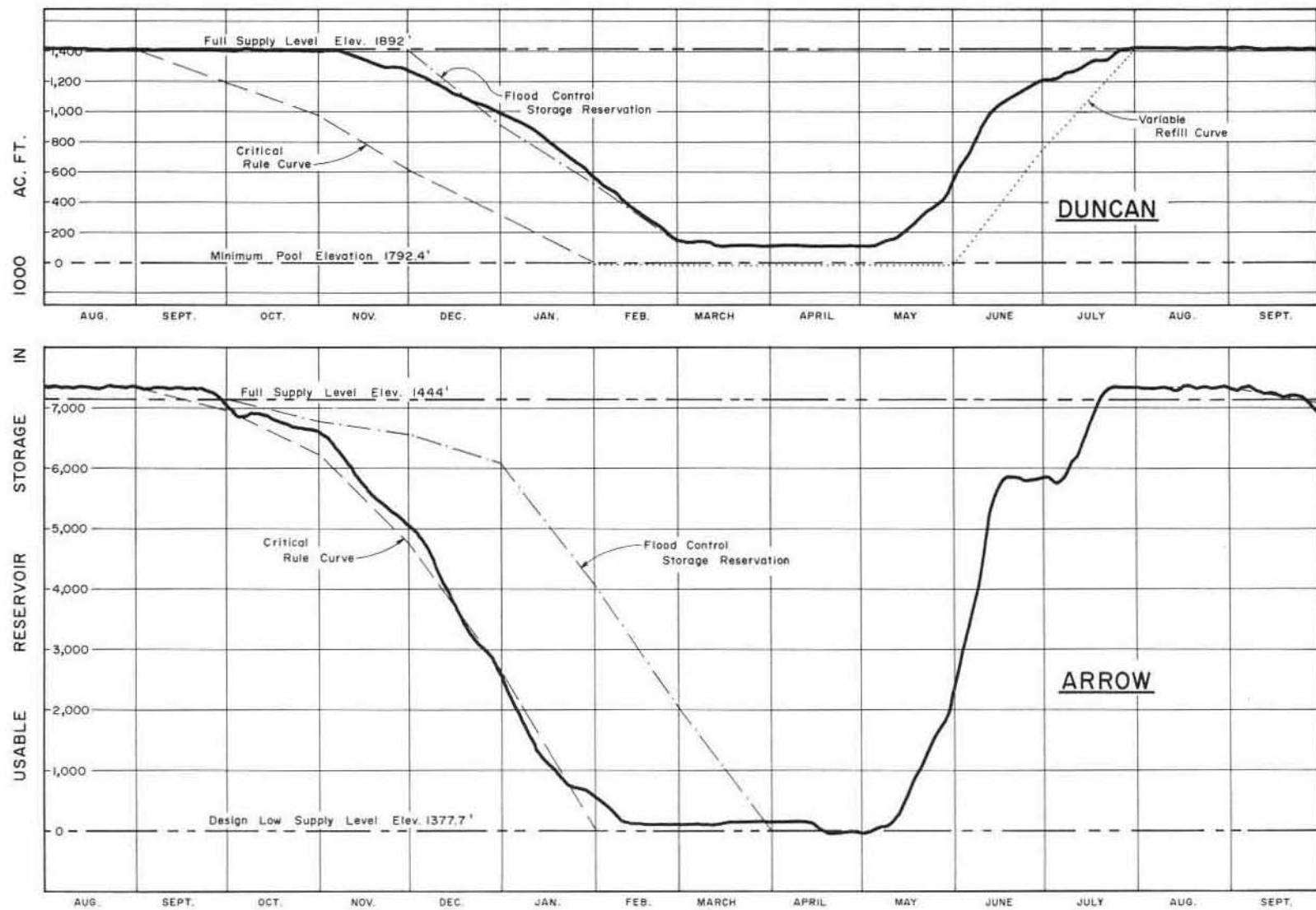


Treaty Storage 1 July 1971 through 31 July 1972" and the "Detailed Operating Plan for Columbia River Treaty Storage 1 July 1972 through 31 July 1973". Operations were in accordance with committee directives normally issued on a weekly basis.

Power Operation

Both the Duncan and Arrow reservoirs were fully operational during the report year and provided reservoir storage to supplement natural streamflow during the storage draft season. Both reservoirs filled completely during the 1972 freshet in a manner consistent with flood control and hydroelectric requirements. An agreement to use two feet of storage in the Arrow reservoir above normal full reservoir level is described in the following section.

Operation of the two reservoirs is illustrated on page 34 by hydrographs which show actual reservoir levels and some of the more important rule curves which govern operation of the Treaty storage. The Flood Control Storage Reservation curve specifies maximum month-end reservoir levels which will permit evacuation of the reservoir to control the forecasted freshet. The Critical Rule Curve shows minimum month-end reservoir levels which should be maintained to enable the anticipated power demands to be met under adverse water supply conditions. The Variable Refill Curve shows reservoir elevations necessary to ensure refilling the reservoir by the end of July with a reasonable degree of confidence. Similar rule curves which apply to operation of the combined storages have also been provided to the Board.



HYDROGRAPHS - Duncan and Arrow reservoir levels for the 14-month period ending 30 September 1972.

At the beginning of the report year Arrow and Duncan reservoirs were at normal full supply levels and use of Treaty reservoir storage commenced in October 1971. Above average water conditions resulted in the Treaty storage being operated to rule curves for power purposes until the end of March 1972 when flood control requirements became the prime consideration.

The Duncan reservoir provided about 1.3 million acre-feet of reservoir storage. This storage was drafted between the beginning of November 1971 and March 1972 to meet the requirement of the Upper Rule Curve which provides space for flood control storage without creating excessive spill. Due to generally high inflows early in 1972 some of the water released from the Duncan reservoir was spilled past the Kootenay River plants. Outflows from the Duncan reservoir were limited by agreement to a maximum of 10,000 cfs. The reservoir began to fill on 5 May 1972, reached normal full pool elevation of 1892 feet on 27 July 1972, and remained full until 30 September 1972.

Release of storage from the Arrow reservoir, which began at the end of September 1971, followed the operating rule curve for the reservoir and early in February the reservoir was close to minimum elevation. The remaining storage was released during April and when the reservoir reached its minimum level a total of 7.1 million acre-feet of stored water had been provided. Controlled storing for flood control in the lower Columbia River commenced on 4 May 1972 and continued through May and June. The reservoir reached normal full pool elevation 1444 feet on 19 July and, by special agreement outside the Treaty for two feet of additional storage space, it reached elevation 1446 feet on 23 July. On 9 September



MICA ACCESS BRIDGE crossing Columbia River, part of road to powerhouse.
September 1972.

drafting of this extra storage commenced and by 30 September 1972 the reservoir was at elevation 1443 feet, slightly below normal full pool.

Libby reservoir, although it filled to elevation 2404.5 feet in 1972, was not operated for power criteria. It is scheduled to fill to design elevation 2459 feet in 1973. After the 1972 freshet a decision was made to evacuate the reservoir to permit remedial work near the dam, and drafting commenced on 12 September and proceeded as rapidly as possible consistent with safety and regulatory limitations. These storage releases contributed to downstream power generation and reduced the need to draft other storages during this period.

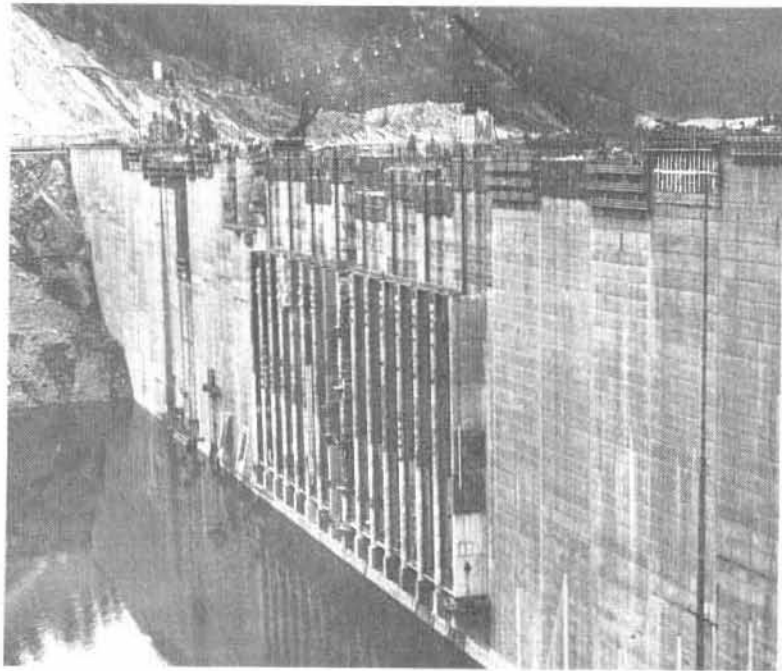
Additional Storage on Arrow Reservoir

By agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration, two feet of storage was provided on Arrow reservoir during the period July to September 1972 in addition to the storage which Canada is required to supply under the terms of the Treaty. Operation above the normal full reservoir elevation of 1444 feet is illustrated in the hydrograph on page 34.

Under Article IV(5) of the Treaty the Board has a responsibility to ensure that operation of additional storage does not reduce the flood control and hydroelectric benefits obtainable from operation of the Treaty storage. The Entities informed the Board of the arrangements for provision of additional storage and of their agreement that its operation would not conflict with any of the arrangements made in connection with the Treaty. The Board concurred with the Entities in this matter.

LIBBY DAM

Selective withdrawal
structure for
penstock intakes.
March 1972.

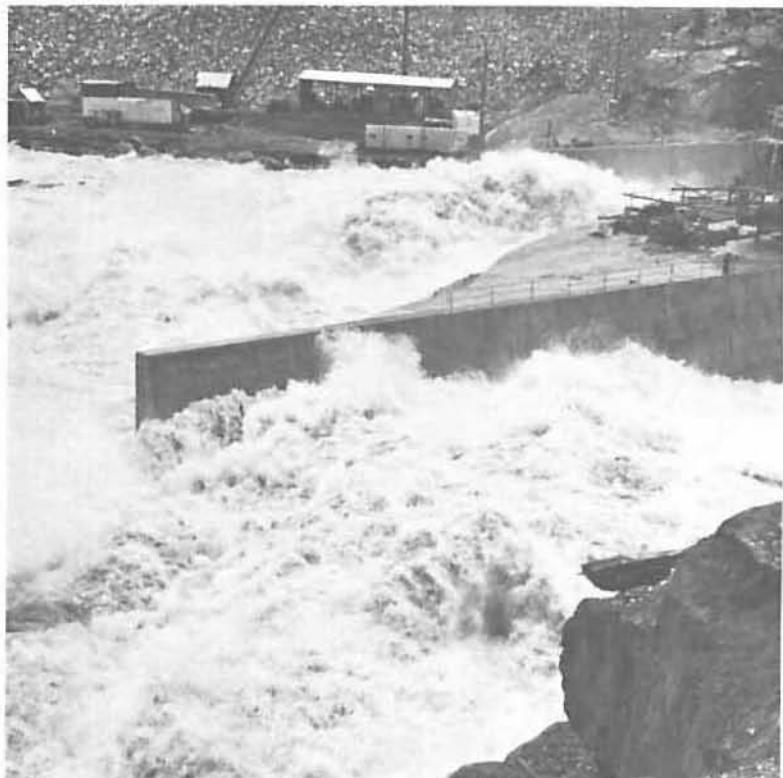


Flood Control Operation

The Entities agreed to operate Treaty storage for flood control during the 1972 freshet in accordance with the objectives of the document "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs" and of the draft document "Columbia River Treaty Flood Control Operating Plan". The three reservoirs, Arrow, Libby and Duncan, were operated in accordance with these procedures and were effective in preventing damages that would have occurred during this very large freshet. Benefits from flood control operation are described on page 39.

MICA DIVERSION TUNNELS

discharging
record flows.
June 1972.



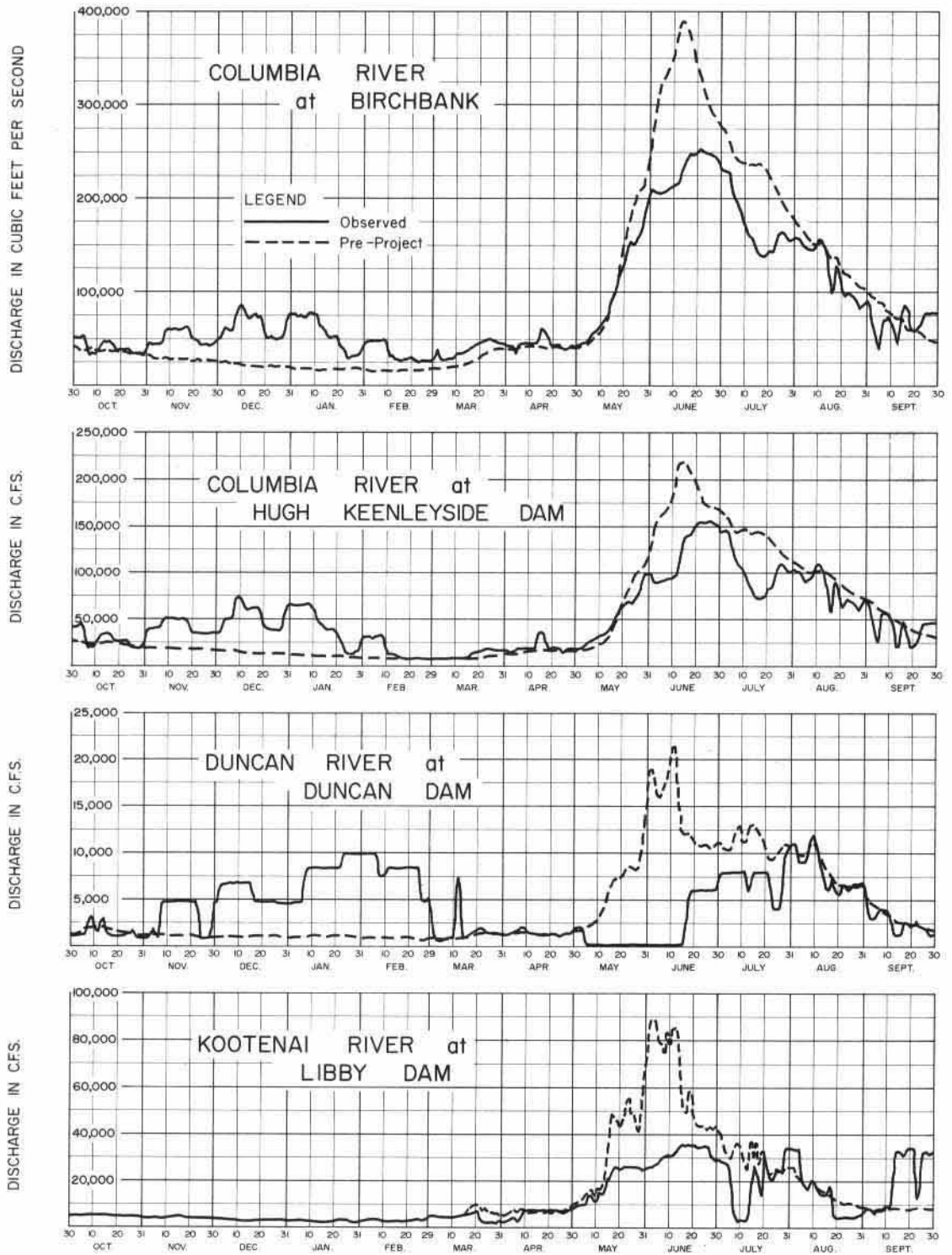
BENEFITS

Flood Control Payment

As described in previous reports, full payment has been made to Canada for all flood control benefits provided by the Arrow and Duncan reservoirs under Article IV(2)(a) for the period covered by the Treaty and for early completion of the two projects. Payment for the incremental protection provided by the Mica project will be due on the date that the project is declared operational.

Flood Control Provided

The 1972 freshet in the Columbia River basin was the largest of this century. It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by about seven feet and that the Duncan, Arrow and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by almost 12 feet. The effect of storage in the Duncan, Arrow and Libby reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on page 40 by hydrographs which show actual discharges and pre-project flows that would have occurred if the dams had not been built. It is noted that the pre-project hydrograph for Birchbank has been computed on the assumption that the effects of Duncan, Arrow and Libby regulation and of the regulation provided by storage on Kootenay Lake have been removed.



HYDROGRAPHS - Observed and pre-project flows for the year ending 30 September 1972.

The operation of Columbia Basin reservoirs for the system as a whole reduced the peak discharge of the Columbia River near The Dalles, Oregon by approximately 432,000 cfs to a flow of 618,000 cfs. The corresponding reduction in peak stage at Vancouver, Washington amounted to about ten feet. The Arrow, Duncan and Libby projects contributed about 31 percent of the total effective storage in the Columbia reservoir system during this period of freshet control of the lower Columbia River.

In summary, the availability of the Treaty storage during the freshet period of 1972 prevented substantial flooding in both Canada and the United States.

Power Benefits

Downstream power benefits in the United States which arise from operation of the Canadian Treaty Storage were pre-determined and the Canadian one-half share was sold in the United States under the terms of the Canadian Entitlement Purchase Agreement for a 30-year period. No additional downstream power benefits were realized during the year from the operation of Treaty dams other than the added generation made possible on the Kootenay River in Canada and the benefits in the United States from the added two feet of storage provided by the Arrow reservoir. The Kootenay River benefits in Canada, under Article XII of the Treaty, are retained wholly within Canada. The benefits resulting from the added storage in the Arrow reservoir were the subject of a separate agreement between the British Columbia Hydro and Power Authority and the Bonneville Power Administration.

CONCLUSIONS

1. The Duncan and Hugh Keenleyside Dams are complete. The Mica and Libby projects are proceeding on schedule and both will be operational in 1973.
2. Entity studies pertaining to development of the hydrometeorological network, power and flood control operating plans, and the annual calculation of downstream power benefits are proceeding satisfactorily.
3. The Duncan and Arrow projects have been operated in conformity with the provisions of the Treaty, the detailed operating plans developed by the Entities, the interim flood control operating plan for Duncan and Arrow reservoirs, and the draft flood control operating plan for Treaty reservoirs.
4. The partial operation of Libby this year met the operating criteria of the Treaty.
5. The operation of additional storage in Arrow reservoir did not adversely affect the benefits obtainable from operation of the Treaty storage.
6. Finally, the Board concludes that the objectives of the Treaty are being met.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

<u>United States</u>	<u>Canada</u>
<u>Members</u>	
Mr. Joseph M. Caldwell, Chairman Chief, Engineering Division, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. G. M. Mac Nabb, Chairman Assistant Deputy Minister, Energy Development, Department of Energy, Mines and Resources, Ottawa, Ontario
Mr. John W. Neuberger Chairman, Missouri River Basin Commission, Omaha, Nebraska	Mr. A.F. Paget Consulting Engineer, Victoria, B.C.
<u>Alternates</u>	
Mr. Fred L. Thrall Chief, Western Reports Management Branch, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. E.M. Clark Regional Engineer, Engineering Division, Water Planning & Management Branch, Department of the Environment, Vancouver, B.C.
Mr. J. Emerson Harper Assistant and Power Engineering Advisor, Office of the Assistant Secretary for Water and Power Development, Department of the Interior, Washington, D.C.	Mr. H.M. Hunt Chief, Power and Major Licenses Division, Water Resources Service, Department of Lands, Forests and Water Resources, Victoria, B.C.
<u>Secretaries</u>	
Mr. Walter W. Duncan (1) Chief, Reservoir Regulation Section, Hydrologic Engineering Branch, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. E.M. Clark Regional Engineer, Engineering Division, Water Planning & Management Branch, Department of the Environment, Vancouver, B.C.

(1) Vice Mr. Verle Farrow as of 20 March 1972.

COLUMBIA RIVER TREATY ENTITIES

United States

Mr. H.R. Richmond, Chairman
Administrator, Bonneville
Power Administration,
Department of the Interior,
Portland, Oregon

Major General K.T. Sawyer

Division Engineer, North
Pacific Division,
Corps of Engineers,
U.S. Army,
Portland, Oregon

Canada

The Honourable R.G. Williston, Chairman
Minister of Lands, Forests and Water
Resources,
Victoria, B.C.

RECORD OF FLOWS

AT THE

INTERNATIONAL BOUNDARY

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	51,500	47,300	50,500	76,700	47,100	31,400	42,500	43,500	210,000	230,000	158,000	85,100
2	50,600	46,900	55,200	76,800	48,800	39,500	41,200	44,000	207,000	230,000	158,000	70,400
3	50,500	44,200	61,700	74,900	49,200	33,400	41,200	45,100	205,000	229,000	156,000	59,300
4	54,800	45,500	60,400	76,300	47,400	27,600	34,200	45,800	206,000	225,000	151,000	47,100
5	50,000	44,900	58,900	75,600	49,300	27,100	43,000	49,300	206,000	207,000	147,000	38,800
6	38,200	45,200	58,900	73,300	48,100	28,000	46,600	54,000	207,000	200,000	147,000	53,600
7	32,300	48,000	65,100	76,300	49,100	29,200	45,700	57,200	208,000	195,000	146,000	70,400
8	36,100	58,700	76,100	79,700	50,400	29,100	46,800	59,500	209,000	187,000	145,000	70,100
9	34,100	60,500	83,400	77,200	48,000	29,100	46,200	61,400	212,000	183,000	148,000	73,300
10	35,700	59,800	86,800	76,700	39,800	32,500	45,800	65,100	214,000	175,000	156,000	70,500
11	40,800	60,900	84,800	75,400	30,800	35,400	45,000	67,300	215,000	165,000	157,000	63,600
12	43,600	61,700	77,100	65,000	32,000	34,900	44,700	70,300	216,000	159,000	153,000	51,600
13	47,500	60,200	71,100	63,800	27,700	36,300	45,600	74,800	223,000	158,000	146,000	44,400
14	47,400	59,200	72,300	59,100	28,900	36,700	53,300	82,000	233,000	152,000	132,000	56,900
15	48,300	60,500	76,200	54,100	27,400	37,400	60,300	90,100	238,000	144,000	116,000	79,600
16	46,500	62,000	77,200	52,300	27,400	40,300	59,800	97,500	244,000	140,000	99,800	87,600
17	44,500	63,700	73,400	51,700	29,600	41,600	57,100	107,000	248,000	138,000	110,000	82,100
18	38,600	62,300	74,600	53,000	28,800	43,400	50,200	118,000	247,000	138,000	128,000	72,200
19	39,600	51,800	66,200	53,200	30,700	45,200	42,000	124,000	248,000	139,000	125,000	59,000
20	38,200	48,700	54,300	50,300	30,400	46,300	44,000	132,000	250,000	144,000	110,000	58,600
21	39,200	49,400	51,400	44,600	29,700	47,600	44,500	140,000	253,000	144,000	97,800	61,600
22	39,400	47,600	51,800	41,300	27,900	48,500	44,200	149,000	252,000	143,000	95,800	63,900
23	40,000	43,500	53,600	35,200	25,100	49,000	42,900	153,000	250,000	149,000	99,600	68,900
24	37,800	43,700	49,700	29,900	26,900	50,600	39,800	150,000	250,000	159,000	96,800	76,600
25	34,300	44,900	48,000	31,000	27,900	49,100	38,100	153,000	249,000	164,000	95,300	78,300
26	34,300	44,300	50,400	31,500	27,200	48,600	39,100	158,000	248,000	165,000	91,700	77,100
27	34,900	42,500	51,800	32,500	27,000	47,400	41,400	162,000	245,000	163,000	86,100	77,500
28	35,600	44,200	56,300	32,000	27,000	47,100	43,000	175,000	242,000	159,000	81,800	78,100
29	34,900	45,400	66,800	33,800	27,200	45,900	42,300	186,000	239,000	154,000	86,200	78,300
30	33,600	48,600	75,500	38,600		44,600	42,900	196,000	233,000	156,000	89,300	78,700
31	40,800		78,600	44,600		43,900		207,000		158,000	90,400	
Mean	41,100	51,500	65,100	56,000	35,100	39,600	45,100	107,000	230,000	169,000	123,000	67,800

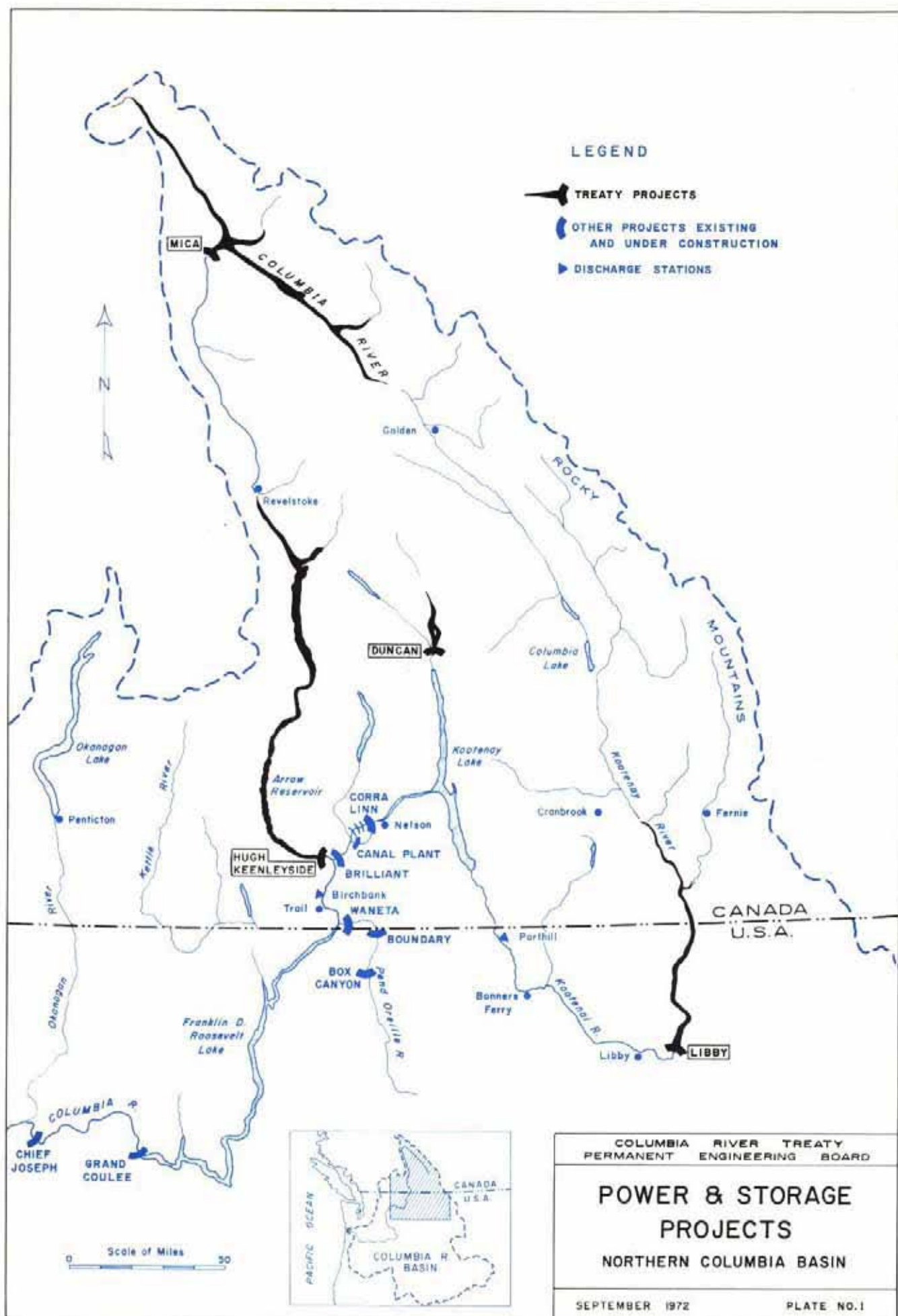
COLUMBIA RIVER AT BIRCHBANK, B.C. - Daily discharges for the year ending 30 September 1972 in cubic feet per second.

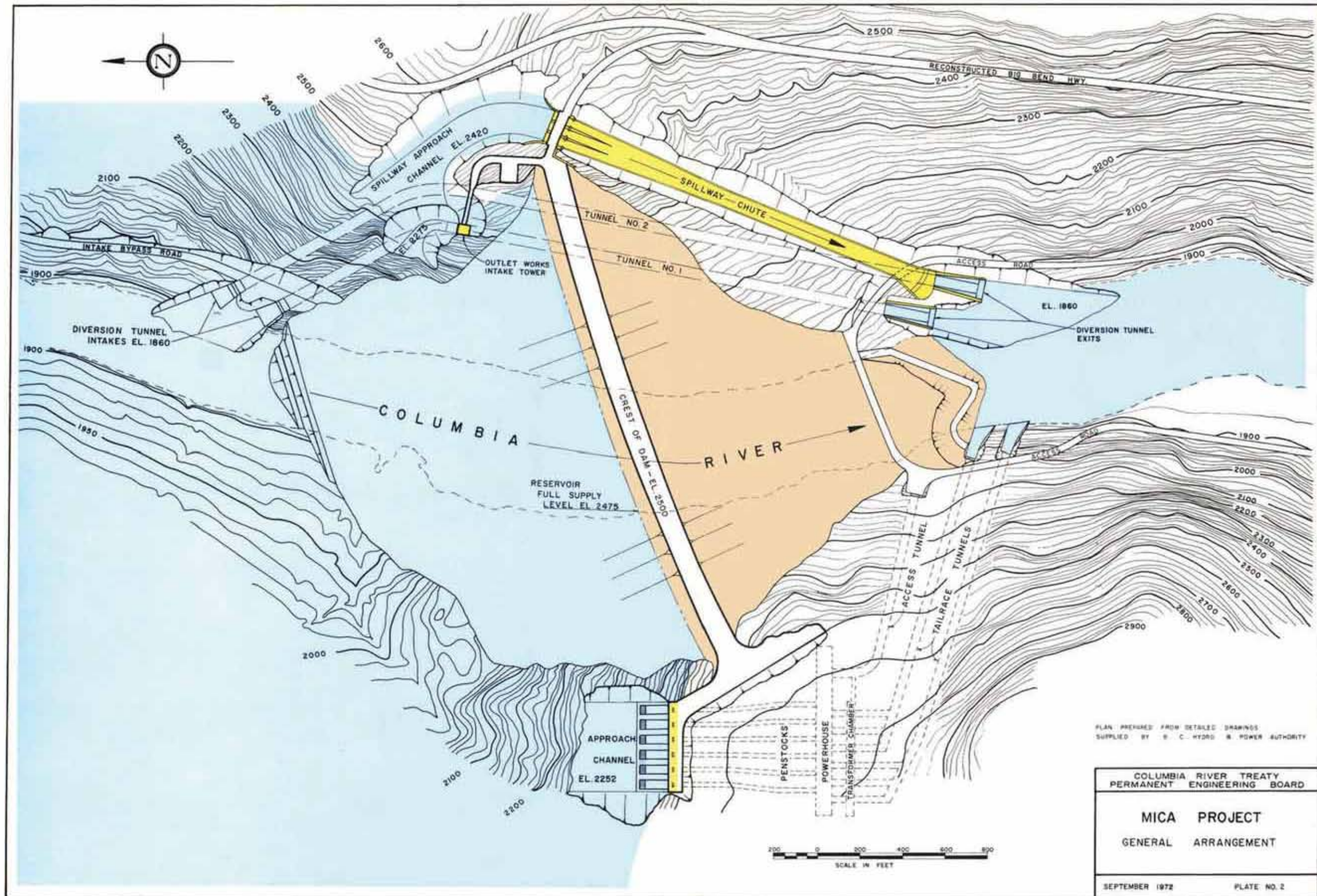
Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	6,120	4,920	4,610	2,350	2,510	17,200	10,000	17,800	60,200	38,500	34,500	7,580
2	5,950	4,690	4,270	2,380	2,710	13,800	10,100	18,400	57,900	37,700	31,800	8,040
3	5,950	5,010	4,340	2,620	2,910	11,400	11,400	19,600	54,900	36,600	36,000	7,800
4	5,910	5,640	4,050	2,800	3,240	9,820	11,900	21,000	51,700	35,300	36,300	7,340
5	5,760	5,410	3,840	2,940	3,610	8,910	12,300	23,300	50,500	35,300	27,100	6,440
6	5,680	5,510	3,680	2,990	3,760	9,360	13,200	26,100	51,100	26,400	21,100	7,360
7	5,750	5,070	3,400	3,010	3,350	10,400	14,200	28,300	51,500	20,000	18,200	7,670
8	5,920	4,760	3,040	2,870	3,310	9,790	15,800	28,800	51,800	13,100	17,400	7,810
9	6,060	4,440	2,850	2,770	3,480	9,340	17,500	28,000	51,800	10,700	21,100	8,200
10	6,110	4,790	2,700	2,560	3,580	9,190	17,200	27,600	51,700	10,100	21,300	8,800
11	6,220	5,470	2,670	2,460	3,720	10,600	16,600	31,200	51,200	9,380	18,400	8,850
12	5,920	5,740	2,600	2,390	3,820	12,600	16,200	33,500	49,900	9,500	17,400	8,730
13	5,910	5,990	2,600	2,400	3,970	13,900	15,700	37,500	49,900	10,800	15,800	17,200
14	6,130	5,840	2,580	2,430	4,050	17,000	15,200	45,000	48,700	14,800	15,100	30,200
15	6,320	5,800	2,620	2,450	4,120	18,000	14,600	52,100	48,500	28,100	13,600	32,200
16	6,390	5,660	2,720	2,500	4,490	18,400	14,600	55,300	48,900	31,800	15,100	32,500
17	6,070	5,330	2,860	2,580	5,020	22,600	14,300	57,700	48,300	30,700	17,900	30,800
18	5,920	5,170	3,020	2,780	5,500	27,200	13,800	59,800	47,400	27,600	17,000	31,700
19	5,700	5,010	3,170	3,130	5,520	27,700	12,300	56,500	46,800	19,500	8,250	32,700
20	5,930	5,030	3,220	3,580	5,410	26,400	11,100	55,000	46,200	35,000	5,780	33,000
21	5,870	4,770	3,200	3,630	5,060	24,300	10,900	55,300	46,500	33,300	6,280	33,700
22	5,800	4,980	3,240	3,580	5,450	19,100	11,100	56,100	46,500	30,900	5,860	33,000
23	5,740	5,060	3,180	3,390	5,410	17,300	11,900	55,800	46,100	26,100	5,850	16,600
24	5,670	5,170	3,130	3,040	5,300	16,900	13,200	53,300	46,100	24,300	5,850	15,800
25	5,400	5,090	3,000	2,760	5,100	15,900	12,700	49,600	45,400	29,100	5,650	28,300
26	5,800	4,960	2,840	2,530	4,950	14,400	12,300	47,300	45,300	29,700	5,640	31,300
27	5,940	5,070	2,780	2,360	5,140	13,000	12,500	46,400	44,600	28,100	5,380	32,400
28	5,690	4,970	2,700	2,220	7,630	11,900	13,800	48,200	40,900	26,700	5,330	31,800
29	5,440	4,870	2,550	2,110	14,800	10,900	15,900	52,000	40,000	34,400	5,700	31,600
30	5,230	4,740	2,370	2,020		10,400	17,400	53,700	38,900	35,800	6,080	31,400
31	4,860		2,370	1,950		10,300		58,800		35,800	6,510	
Mean	5,840	5,170	3,100	2,700	4,720	15,100	13,700	41,900	47,600	26,300	15,300	20,700

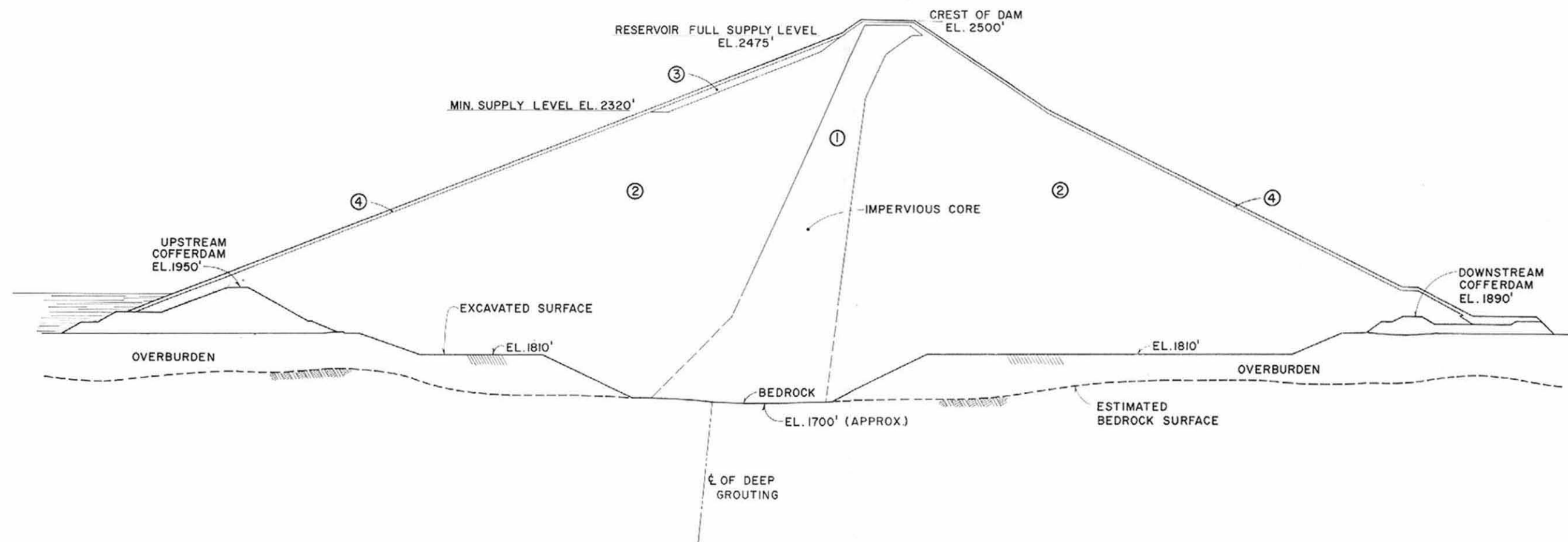
KOOTENAI RIVER AT PORTHILL, IDAHO - Daily discharges for the year ending 30 September 1972 in cubic feet per second.

LIST OF PLATES

	<u>Plate No.</u>
Power and Storage Projects Northern Columbia Basin	1
Mica Project General Arrangement	2
Mica Project Progress Chart of Dam	3
Mica Project General Project Area	4
Libby Project General Arrangement	5
Libby Project Reservoir Area	6

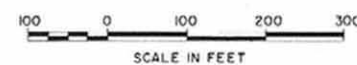






ZONE	MATERIAL
①	IMPERVIOUS FILL
②	PERVIOUS FILL
③	FILTER
④	RIP RAP

EMBANKMENT SECTION



PLAN PREPARED FROM DETAILED DRAWINGS
SUPPLIED BY B.C. HYDRO & POWER AUTHORITY.

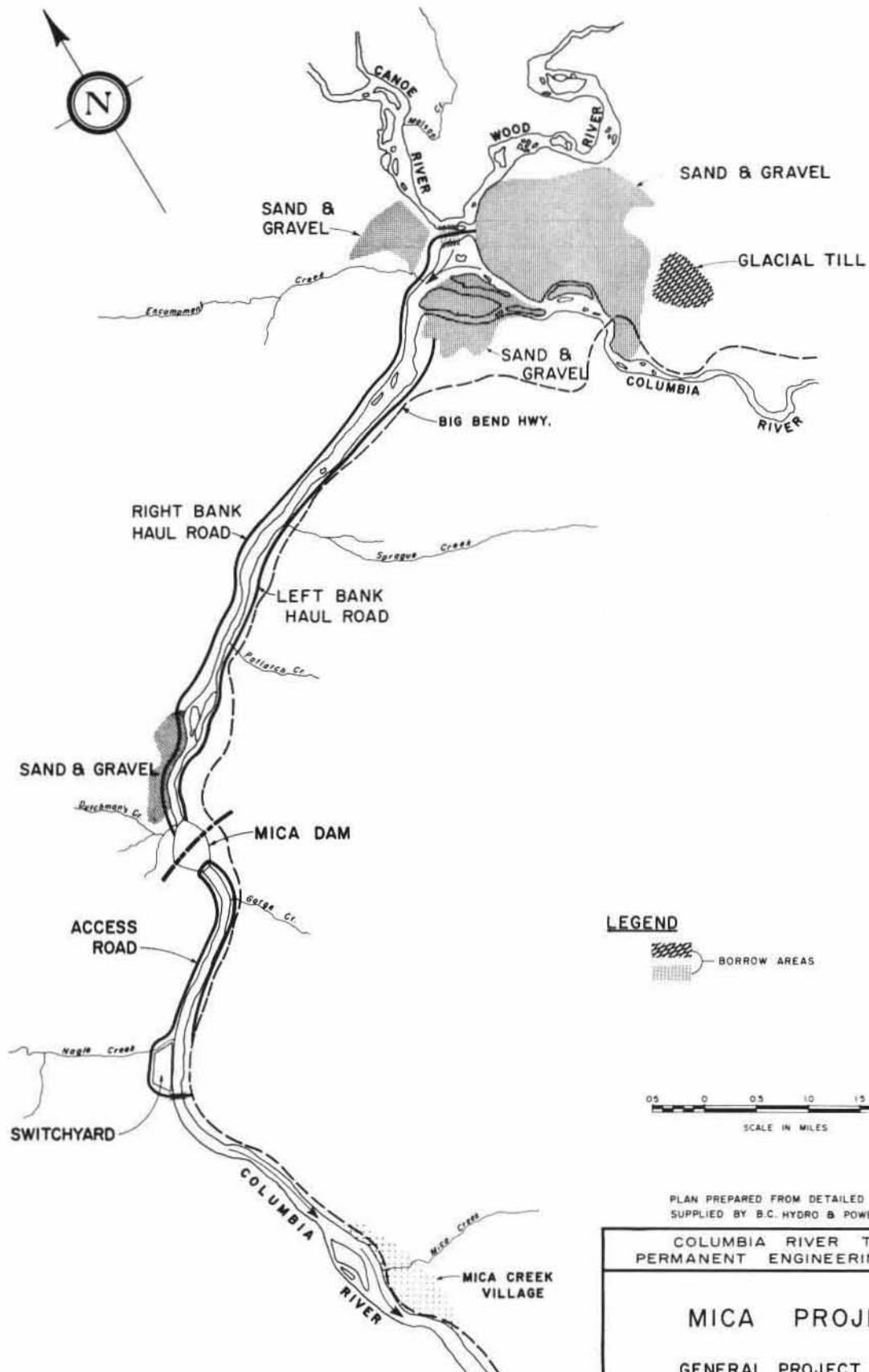
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

MICA PROJECT

EARTH DAM

SEPTEMBER 1972

PLATE NO. 3



PLAN PREPARED FROM DETAILED DRAWINGS
SUPPLIED BY B.C. HYDRO & POWER AUTHORITY.

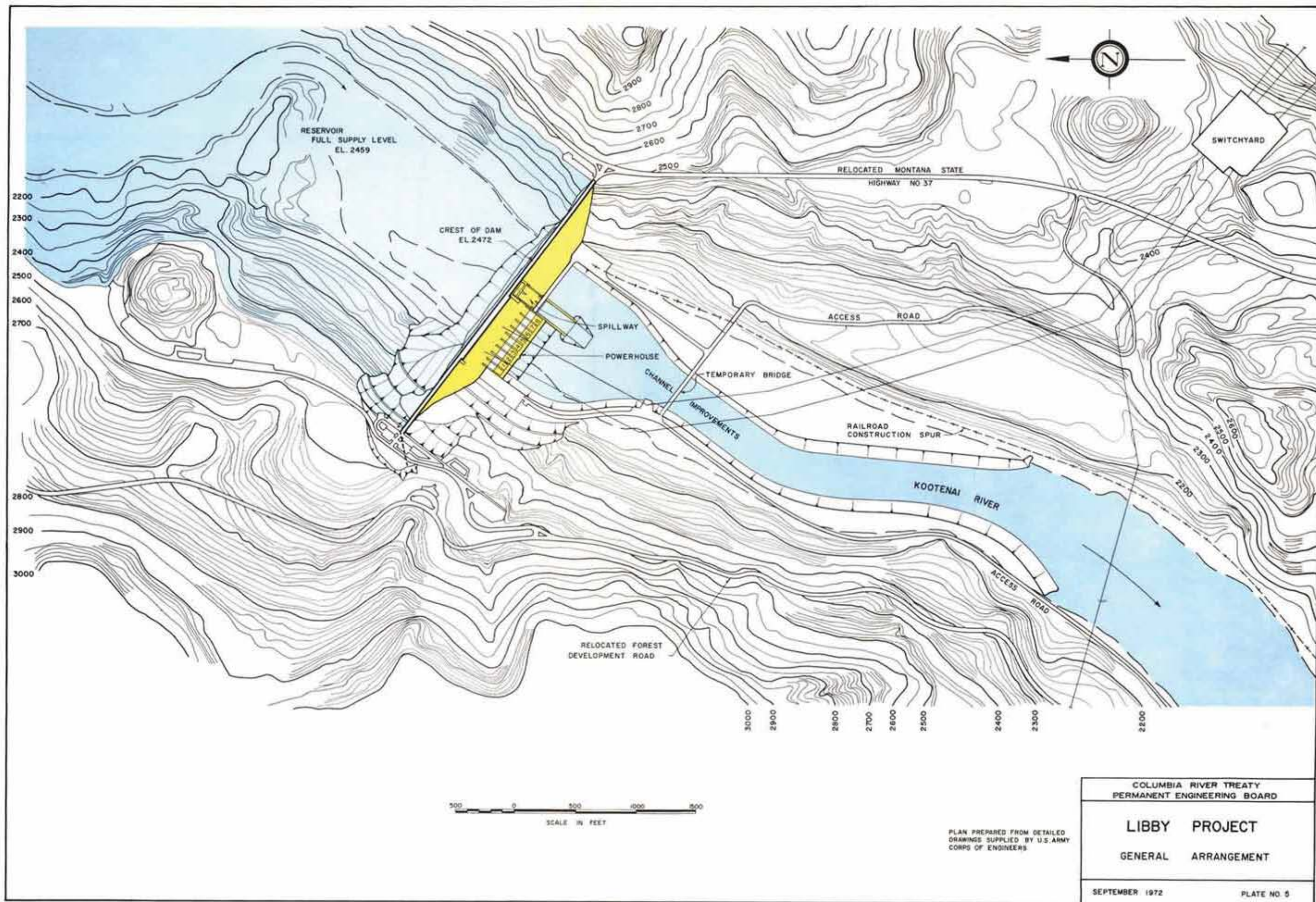
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

MICA PROJECT

GENERAL PROJECT AREA

SEPTEMBER 1972

PLATE NO. 4



COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

LIBBY PROJECT
GENERAL ARRANGEMENT

SEPTEMBER 1972

PLATE NO. 5

